High sensitivity mapping of ammonia emission in the Trumpler 14/Car I photodissociation region

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1 Introduction

As the largest and brightest nebula in the southern hemisphere; and renowned for its concentration of high mass stars, the molecular environment of the Carina Nebula has been the subject of several studies. Of particular interest are the feedback triggered star formation processes occurring within the associated dark clouds and their associated photodissociation regions (PDR). The Trumpler 14 (Tr 14) and Trumpler 16 star clusters together contain over 30 O stars, which contribute significantly to the energy input of the region. At a distance of 2.3 kilo-parsecs, the Trumpler 14 cluster represents an excellent opportunity to study the molecular properties of a photodissociation region as extreme as the 30 Doradus star forming region.

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2 Observations and Results

The observations were conducted with the Tidbinbilla 70-m telescope using the 23 GHz band and amounted to 15 hours spread across several days in January 2011. We used the ATNF correlator to process two IFs with 64-Mhz bandwidth and 2048 channels. We observed a 3.0 arcmin by 1.5 arcmin map (a 10 by 5 grid of pointings), centred at RA 10h43m20s, Dec $-59°34'00''$ (J2000) centred at the peak emission of CO, using the position-switch method with 8 minute integrations per pointing.

2.1 Analysis

We implemented a new data reduction pipeline to produce maps of the molecular emission observed with the Tidbinbilla radio telescope. The pipeline was designed to take advantage of three pre-established Australia Telescope National Facility (ATNF) reduction packages: 1. the ATNF spectral analysis package ASAP; 2. GRIDZILLA, part of the combined LIVEDATA and GRIDZILLA; and 3. MIRIAD.

2.2 Emission and Parameter maps

In the Car I observation, emission spectra were obtained which enabled us to measure the radial velocities, peak and integrated line temperatures. Emission maps of the NH_3(1,1), (2,2) and (3,3) levels are obtained (Fig. 1). The integrated intensity emission maps are sliced in velocity to best illustrate the two distinct clouds of ammonia. In Fig. 2 we present the parameter maps derived using the newly implemented reduction pipeline and calculations using the standard analytical interpretation of ammonia emission.

In order to verify the parameter maps derived with the data reduction pipeline a separate observation was centred on Right Ascension 10h20m00s and Declination $-59°34'30''$ (J2000). With an integration time of one hour we were able to obtain greater than three sigma detections for the satellite hyperfine components. These were used to separately derive the parameters, ensuring results were consistent. This observation is presented in Fig. 3.

3 Conclusion

We observed for the first time molecular emission of ammonia in the region associated with the Trumpler 14 photodissocation region. The first time mapping of this region has led to the derivation of: optical depths which are found to be in the range of $0.75 < \tau_{(1,1,m)} < 2$; temperatures, with kinetic temperatures typically around 30-40 K but as high as 60 K close to the Trumpler 14 cluster; and column densities as high as 8×10^{13} cm^{-2} in the centre of the brightest core. Together these parameters indicate that this site is expected to be undergoing star formation.

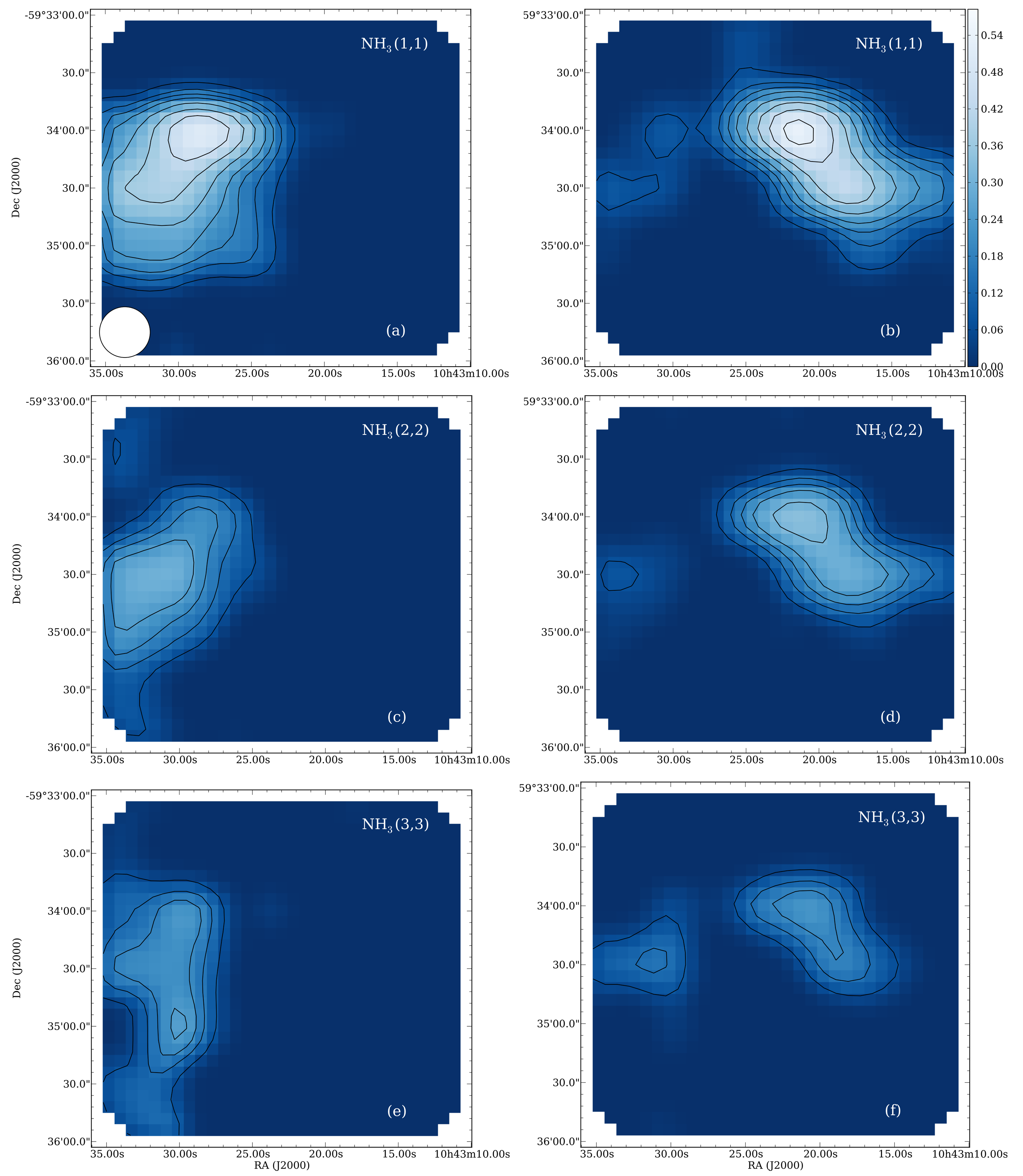

Figure 1: The integrated intensity (K km s^{-1}) maps for the first, second and third (top to bottom respectively) metastable transitions of ammonia in Car I. The horizontal axis is the right ascension coordinate and the vertical axis is the declination coordinate. The white-blue colour-scale represents the integrated intensity of the main hyperfine at the interpolated pixel. The contour levels begin at σ and proceed in steps of σ afterwards (0.07, 0.14, 0.19, 0.24, 0.3, 0.37, 0.44, 0.51) K km s^{-1}. The left and right columns denoted by (a) and (b) for the first metastable level, (c) and (d) for the second and (e) and (f) for the third are slices over the velocity ranges -21 to -25 km s^{-1} (left) and -17 to -21 km s^{-1} (right) respectively. The primary beam size is indicated by the white circle in panel (a).

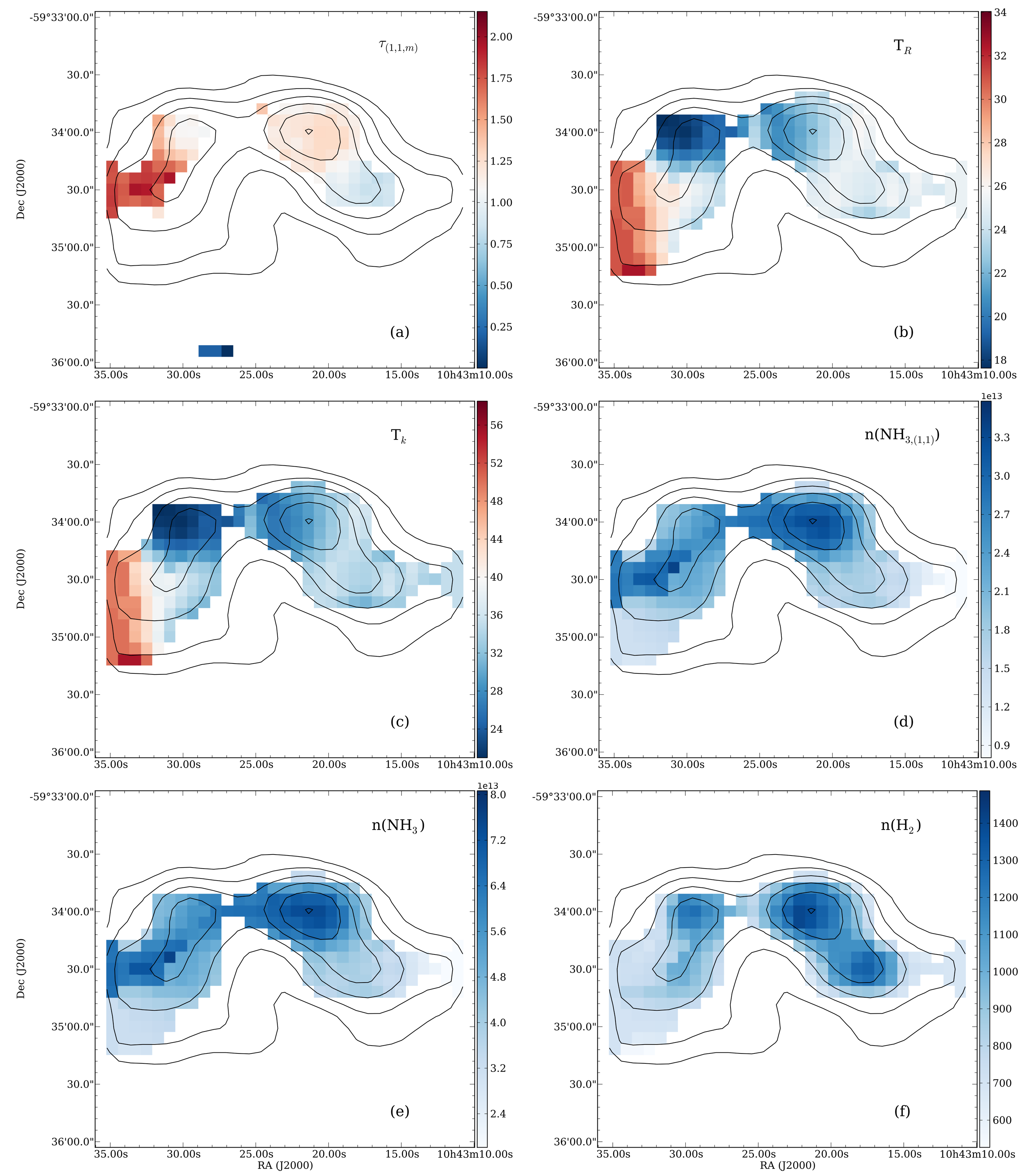

Figure 2: ((a) $\tau_{(1,1,m)}$) The measured main hyperfine optical depth for the first metastable transition of ammonia. The white-blue colour scale indicates the value of optical depth. ((b) T_R) The derived rotational temperature map. The white-blue colour scale represents the rotational temperature value in units of Kelvin. ((c) T_K) The inferred kinetic temperature using the Tafalla relation TAF04. The white-blue colour scale represents the temperature value in units of Kelvin. ((d) n($NH_{3,(1,1)}$)) The column density for ammonia in the first metastable inversion state. The white-blue colour scale represents the column density value in units of particles.cm^{-2}. ((e) n(NH_3)) The total column density for ammonia assuming LTE. ((f) n(H_2)) The density of molecular hydrogen denoted by the white-blue colour-scale in units of particles.cm^{-3} assuming a simple two level system. Each image has the peak intensity contours overlaid (0.04, 0.08, 0.11, 0.14, 0.18, 0.22, 0.26, 0.30, 0.34) K

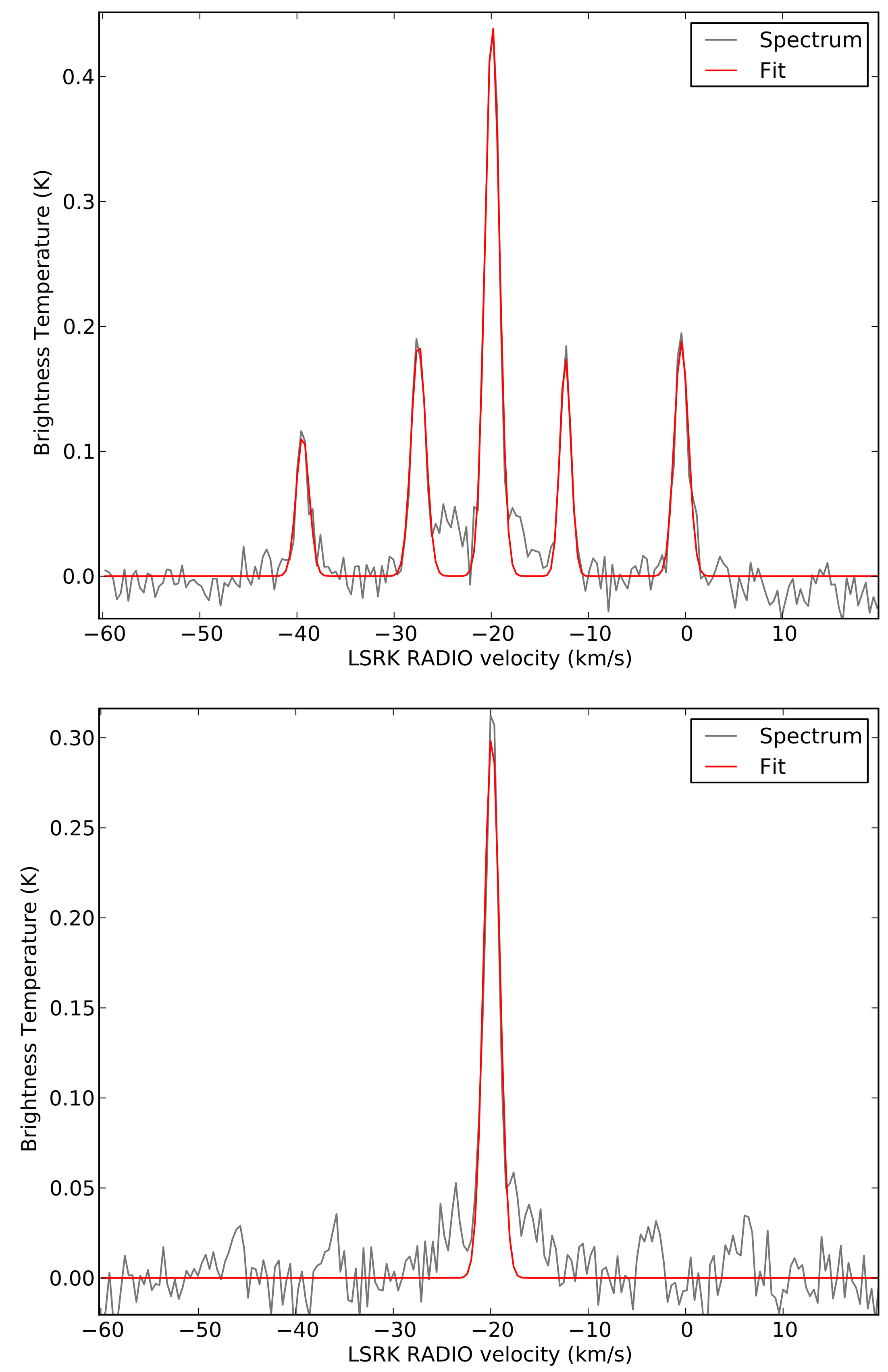

Figure 3: (*Top*) Spectrum of the (1,1) metastable inversion line of ammonia with the Gaussian fits overlaid. The main peak is located at -20 km s^{-1} with the satellite hyperfines located at the expected velocity offsets. (*Bottom*) Spectrum of the (2,2) metastable inversion line of ammonia with the Gaussian fit overlaid. The vertical axis is the brightness temperature in units of Kelvin. The spectral axis is in units of km s^{-1} at the local standard of rest kinematic frame. Note that hyperfines for the (2,2) transitions are weakly present and although it would be possible to fit these and use the (2,2) optical depth to work out temperatures, this is not necessary if one assumes the same linewidths for the (1,1) and (2,2) transitions. The possibility of serving as a consistency check is also mitigated by the low signal to noise on the (2,2) hyperfines.

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